Harrington Beach State Park-North, Wisconsin

Located in the Town of Belgium, Harrington Beach State Park is a 715-acre unit within the Wisconsin State Park System. Annual visitation is estimated at 125,000, with the heaviest use occurring during the summer. In 2010, Harrington Beach was converted from a day-use only park to an overnight facility, with the construction of a 69-unit campground. Overall, the park has 1.1 miles of beach shoreline, which is divided into north and south sections (Harrington Beach-North and Harrington Beach-South, respectively) by a peninsula near the midpoint. There are no lifeguards and the beaches are not regularly groomed.

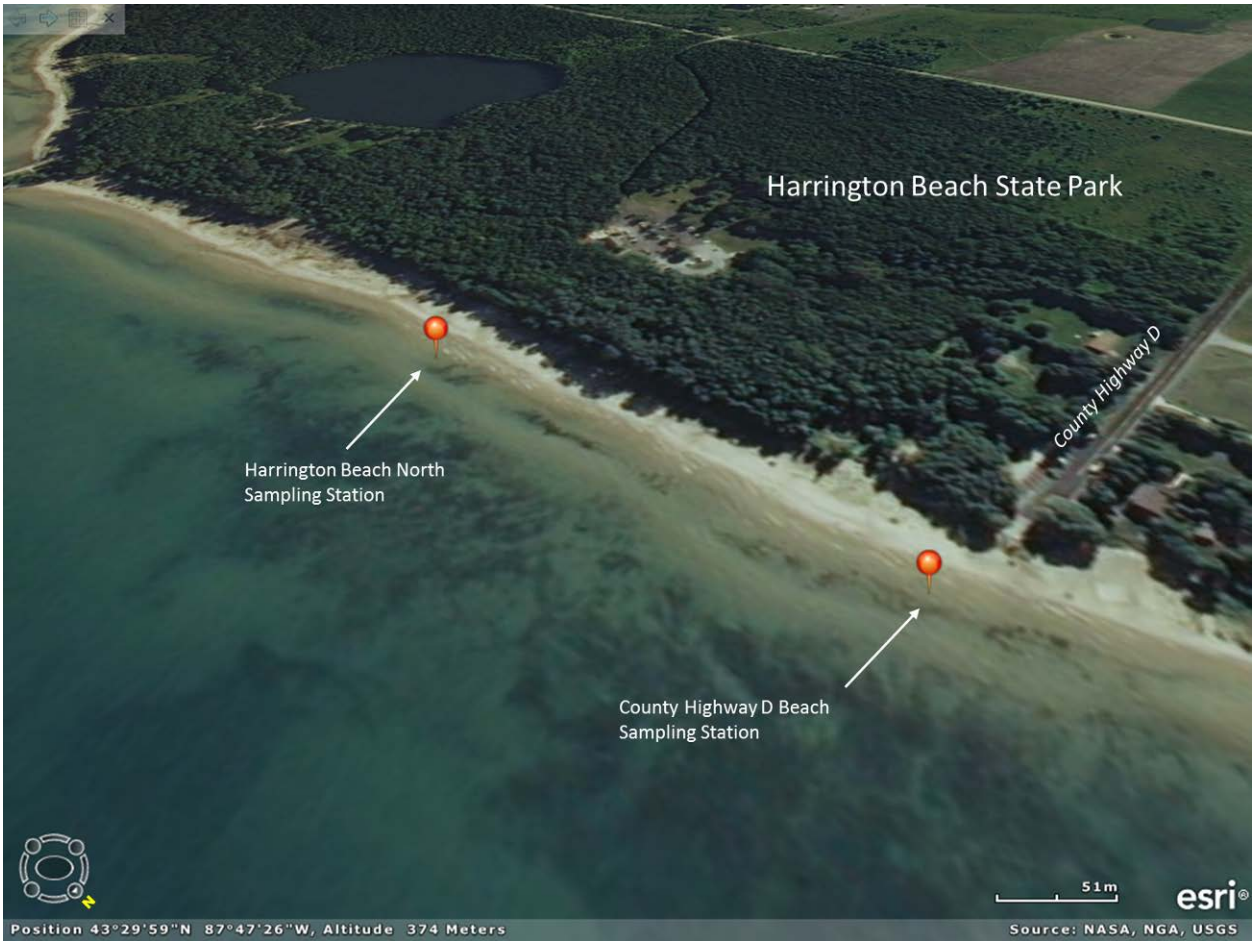

Figure 1. *Harrington Beach State Park "North" and "County Highway D Beach".*

Figure 1 shows the northern portion of Harrington Beach State Park, running south from the park boundary at County Highway D to the peninsula at the near mid-point of the shoreline (approximately 2,500 ft; Harrington Beach-North.). The Ozaukee County Public Health Department monitors water quality and collects samples at two fixed stations (Figure 1) four days per week (Thursday through Sunday). Officially, the northernmost portion is recognized by the U.S. EPA as a separate beach ("County Highway D Beach"). The northernmost sampling station corresponds with this site. From 2008 through 2010, samples from the two sites were composited prior to being transported to the Port Washington drinking water utility lab to be tested for *E. coli* using the standard 18-hour, colilert analysis. The county resumed its earlier practice of maintaining separate samples in 2011.

Water quality at Harrington Beach-North has improved in recent years. Since the resumption of single sample testing, however, the improvement at County Highway D has been less pronounced. In 2010, there were eight posted swim advisories and no closures at Harrington Beach-North (compared with ten advisories and one closure at County Highway D). In 2011, there were just three posted advisories at Harrington Beach-North (compared with six advisories at County Highway D). Although an intensive sanitary survey has never been conducted at Harrington Beach, the disparity in advisories suggests that there is considerable spatial variation in the sources and pathways of *E. coli* contamination. Routine observation and reporting of beach conditions suggests that water quality is heavily influenced by wave height, wave direction, and the level of Cladophora (large fields of which are visible offshore in Figure 1) on the beach and in the nearshore water column.

Nowcast Model

The 2012 beach season was the first with a nowcast model at Harrington Beach–North. For most of the season, however, the nowcast was operated in test-mode only as it proved difficult to predict numerous dry weather exceedances. We could not account for these difficulties, but they appeared to be related to high levels of Cladophera, extreme high water temperatures, and observed mass die-offs of mussels, possibly related to the unusually warm water. Eventually, the model was rebuilt to increase its sensitivity to these unusual conditions. Both versions of the model were built by the Wisconsin DNR using *Virtual Beach 2.2*. Beach monitoring staff at the Ozaukee County Public Health Department provided expert guidance and suggestions based on their long-term observations. The finished models were provided as *Virtual Beach* model (.VBMX) files for local operation using the software. The full process of data assembly, model set-up, and model-building, as well as mid-season evaluation and rebuilding, is described in detail in the report *Building Operational "Nowcast" Models for Predicting Water Quality at Five Lake Michigan Beaches*[1].

The 2012 Harrington Beach–North nowcast model was specified as:

LOG10(*Ecoli*) = 1.068 + 1.008e-05*(SQUARE(*DOY*)) - 0.4291*(*ClearWater_y1_0*) - 56.2*(INVERSE(*WaterTemp_F*,24)) + 0.1606*(POWER(*RRAIN24*,0.33333333)) + 0.0001106*(SQUARE(*RRAIN120*)) + 0.745*(POLY(*WaveA_comp*(WVHT,WVDIR,-11.67),1.1339497,-0.64205924,2.2847268)) - 0.001594*(INVERSE(*CLDCV*,0.0061)) + 0.1343*(SQUARE(*AlgBeach_0-3*))

Where:

Ecoli = *E. coli* (MPN/100mL) — Measured by the Racine Health Dept.
AlgBeach_0-3 = Algae on beach (0"none" – 3"high") — Ozaukee Co. Pub. Health
CLDCV = Cloud Cover (percent) — GLCFS, NOAA
ClearWater = Water "clear"? (y=1/n=0) — Measured by the Ozaukee Co. Pub. Health
DOY = Day of year (1-365)
RRAIN24 = Rainfall, 24 hours (mm) — Radar Est. from the North Central River Forecasting Center, NOAA
RRAIN120 = Rainfall, 5 days (mm) — Radar Estimate…. NOAA
WaterTemp_F = Water Temperature (degrees F) — Ozaukee Co. Pub. Health

[1] Mednick, A.C. 2012. *Building Operational "Nowcast" Models for Predicting Water Quality at Five Lake Michigan Beaches.* PUB-SS-1098. Bureau of Science Services, Wisconsin Department of Natural Resources, Madison.

WaveA_comp = Alongshore Wind (meters/sec) — Derived from:
Significant Wave Height (meters) — GLCFS, NOAA
Wave Direction (from 0-360 deg.) — GLCFS, NOAA

And where:

LOG10 = logarithm, base 10
INVERSE = $1/X$
POLY = polynomial transformation ($a + bX + cX^2$)
POWER = $X^{1/3}$
PROD = $X1 * X2$
SQUARE = X^2

Nowcast Operation

The Harrington Beach–North nowcast was run alternatively by beach monitoring staff at the Ozaukee County Health Department and staff at the Wisconsin DNR, using daily data uploaded to the *Wisconsin Beach Health* website. The process of running the nowcast took the operator five minutes or less, on top of routine beach monitoring and public notification activities. Nowcast model runs were conducted after monitoring personnel returned to the health department office from collecting water samples and taking routine sanitary survey measurements at the beach (Figure 2). Routine sampling and sanitary surveys take place around 06:00 a.m.

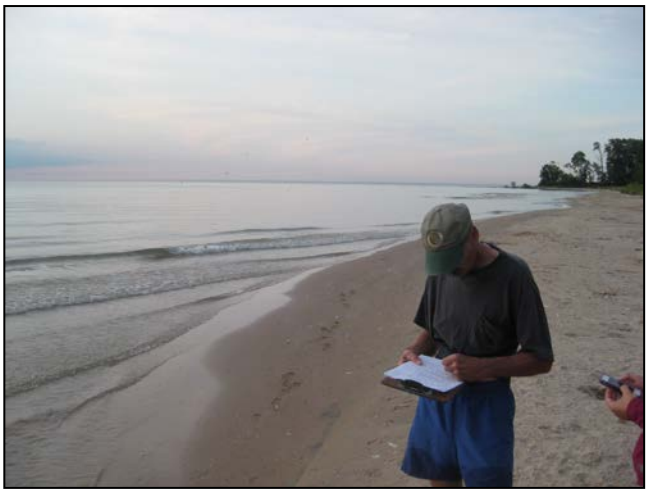

Figure 2. *Beach conditions entered on a routine sanitary survey form.*

The nearshore water at Harrington Beach-North was classified subjectively as “clear,” “somewhat turbid,” “turbid,” or “opaque,” following the routine sanitary survey protocol. On most days, however, beach monitoring personnel also used a turbidity tube (Figure 3) to derive a simple quantitative measure of water clarity (i.e. centimeters of visibility). This measure will likely be used in place of the subjective categories in future nowcasts.

Figure 3. *Using a turbidity tube to measure water clarity.*

The procedure for running the model was for the operator to first access and download "automated" data inputs via the U.S. Geological Survey's *Environmental Data Discovery and Transformation* (ENDDAT) system [2] using a custom ENDDAT web URL developed by Wisconsin DNR staff. Launching the URL downloads a one-row table of the most recent values of several model inputs, including: *RRAIN24* and *RRAIN120* (millimeters of rain estimated by radar over the past 24 and 120 hours), *CLDCV* (percent cloud cover), *DOY* (day of year, 1-365), and *Significant Wave Height* (meters), and *Direction* (0-360 degrees). Next, the operator opened the *Virtual Beach* model (.VBMX) file and imported the daily ENDDAT table into the MLR Prediction tab, leaving the operator to manually-enter three additional values: *WaterTemp_F* (water temperature, degrees F), *ClearWater* (water clarity category is "clear" [1] or not [0]), and *AlgBeach_0-3* (amount of algae on beach, ranging from "none" [0] to "high" [3]). Once all of the input values were entered, the operator executed the model to make a prediction (Figure 4).

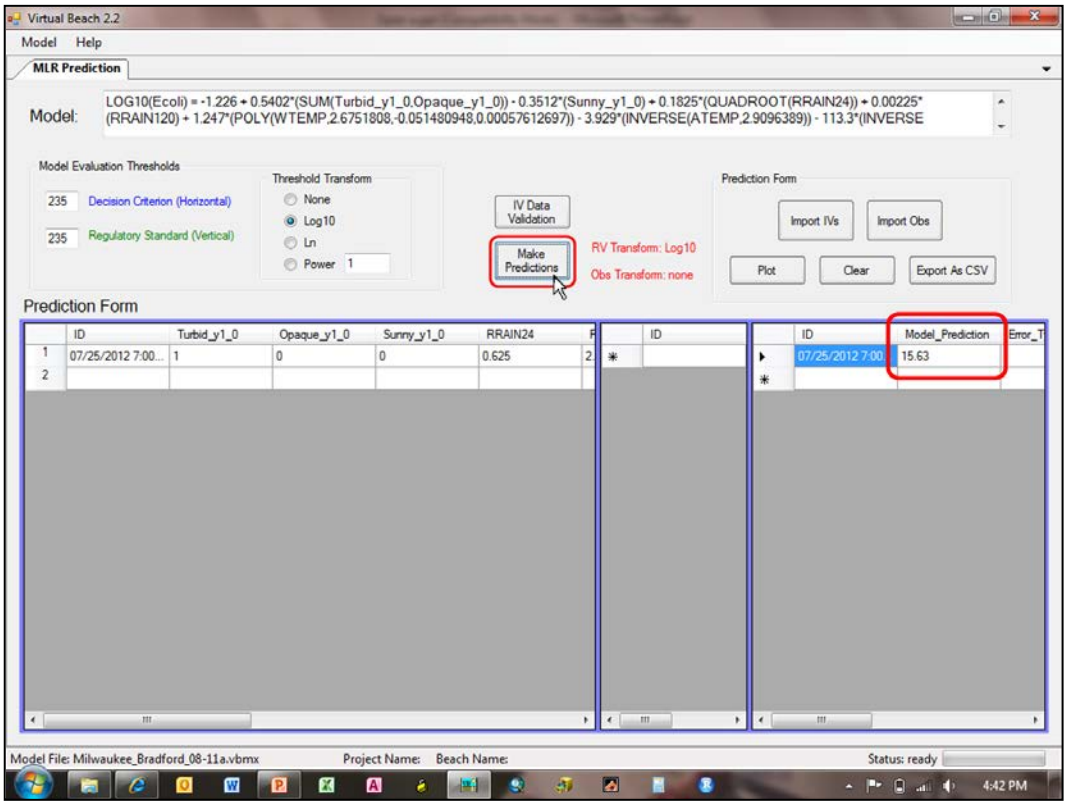

Figure 4. *Virtual Beach, making a prediction.*

Outputs of the nowcast included both the estimated concentration of *E. coli* and the statistical probability of exceeding the 235 CFU/100 mL water-quality standard. As discussed above, the revised nowcast model for Harrington Beach-North did not become operational until the final week of the 2012 beach season. Applied retroactively over the full season, the model proved to be 77% accurate in predicting water-quality exceedances and non-exceedances, compared to 66% for the "persistence method" (i.e. the previous day's lab results).

[2] http://cida.usgs.gov/enddat/

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